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CHESTNUT BLIGHT IN MICHIGAN

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Although chestnut formerly held a leading place among eastern hardwood trees because of its abundance, rapid growth, and wood properties, it has never been commercially important in Michigan for lumber. This is due to the fact that its occurrence in Michigan has been limited to local areas in the southeastern part of the State. Chestnut extends naturally as far north as St. Clair county and it occurs abundantly on the sandy loam soils in eastern Monroe and Wayne counties. (Plate I.) Much of this remaining natural chestnut, however, is threatened by the rapid industrial development and expansion of nearby cities.

A number of chestnut plantations have been established in Michigan with native and hybridized stock. The oldest planting was made, according to the best records available, about sixty-five years ago. (Plate IIB.) Although these trees have been injured by ice storms and have been badly damaged by grazing, the trees continue to produce nut crops. The chestnut here were set out in a sandy loam, 25 to 40 feet apart, and were cultivated for the first 12 or 15 years. Since that time, the area has been closely pastured by sheep and cattle. As a result of this grazing, many of the trees have been injured as indicated by the presence of such chestnut heart-rotting fungi as *Polyporus spraguei* and *P. sulphureus*. As early as 1888, these trees, on an area of about one acre, produced nuts worth $10 or $15 each year (5).[2] Today orchards planted at the same time are producing 5 to 8 bushels of nuts per acre practically every year which bring a price of from $60 to $160 per acre to the grower.[3]

Numerous other plantations are to be found in Michigan. (Plate IIA.) Some of these date back to 1894 and 1896. Measurements given by Chittenden (2) for some of these plantations are presented in Table I.

The 37-year-old planting, according to this author, has yielded 15 bushels of nuts to the acre some years.

In forest plantations of chestnut, the trees are usually spaced 6 by 6 feet instead of the required wider spacings of 20 by 20 feet or more for nut culture. Very few forest plantations, however, have been established in

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[2]The numbers in parentheses refer to the literature cited at the close of this paper.

[3]From information furnished by the late Professor A. K. Chittenden which he obtained through correspondence with owners of chestnut orchards in Michigan.

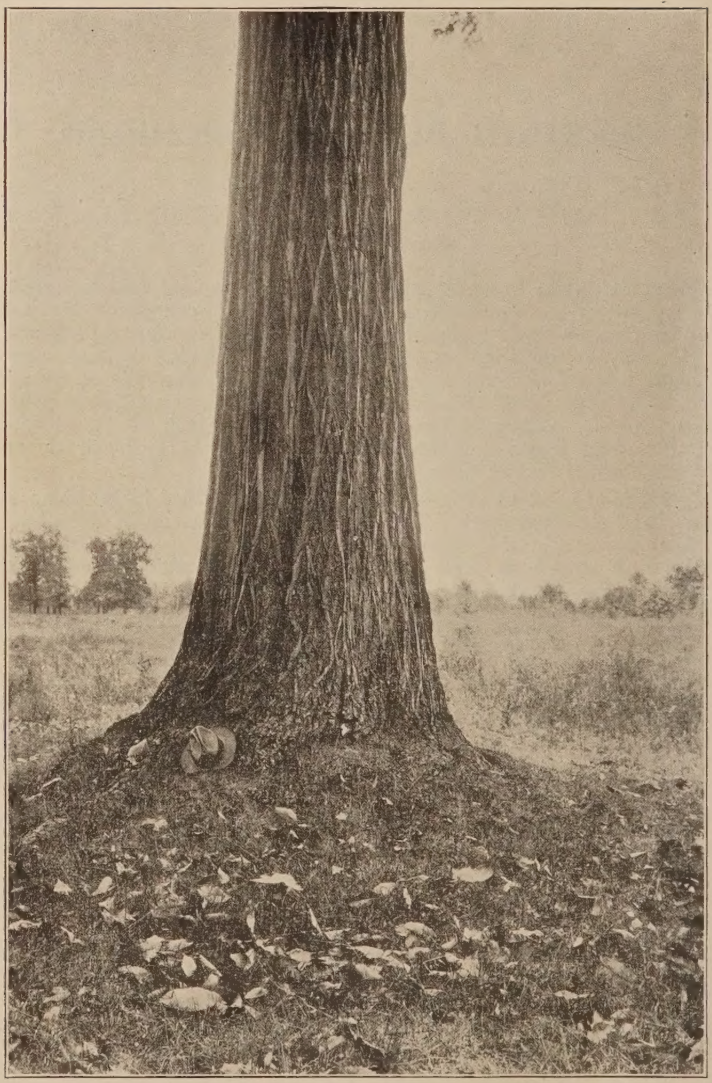

Plate I. Native chestnut near Wayne, Michigan.

Plate II. A. Chestnut Plantation, Western Michigan. Owners of chestnut orchards should make examination of their trees. Blight infections should be pruned out at once in an effort to prolong the life of the tree. B. Chestnut in 65-year-old plantation—the oldest plantation known in the state.

Table I.—Growth of Chestnut in Michigan

Species	Age, years	No. of trees per acre	Diameter average tree, inches	Diameter maximum tree, inches	Height average tree, feet	Yield per acre, cubic feet
Chestnut	12	100	4.0	7.5	20	78
Chestnut	37	67	14.4	20.0	65	2,100
Chestnut	45	51	19.9	27.0	65	2,700

Michigan. The oldest forest trees set out in the state were planted in 1876 by Dr. William James Beal of the Michigan State College. Although many of the trees died, several are still rather successfully competing with such species as oak, beech, maple, and a great variety of other hardwoods as well as conifers.

Referring to this mortality, Coons (3) states, "Dr. Beal, who planted nearly all of the trees and who has watched their growth for years, attributes the death of the trees to severe winters."

The planting of chestnut on sites similar to those found on their experimental forest areas near Ann Arbor is not recommended by the University School of Forestry and Conservation. While other hardwoods, such as sugar maple, cottonwood, black locust, yellow poplar, and red oak, have shown a mean annual height growth of approximately one foot or more, chestnut has shown a mean of less than 0.5 feet. The trees in this plantation were set out in 1906. The trees were planted 6 by 6 in a deep fresh clay loam with little organic matter in the soil. At 19 years of age the average height was only 8.3 feet, according to Young. (6) A great number of the trees were winter-killed in 1910 and in 1911. Mice girdled many of these chestnut trees in 1912, 1913, and 1914. As the vacant spaces in this plantation were filled in with white pine, red oak, and European larch in 1917, and in 1925 with Scotch pine, the plantation is now a mixed one. Although chestnut blight infection occurs on native trees only a few miles east of Ann Arbor, no blight has been found in this plantation.

The Spread of the Chestnut Blight

That chestnut blight infection has spread rapidly from the original center of its introduction at New York City is well known to everyone interested in forestry and chestnut culture. The unchecked spread of the parasite into New England forests and its advance in a southwesterly direction along the slopes of the Blue Ridge and Allegheny mountains has wrought more destruction than any other forest-tree disease known. The blight organism has invaded the forests of the Southern Appalachians and has been found in Ohio, Indiana, Kentucky, and Michigan. Although a spot infection has been reported in a commercial orchard in western Illinois, this blighted chestnut was destroyed.

The chestnut blight was first discovered in Michigan in 1916. It was found on Paragon nursery stock which had been shipped into this state from New York and planted in the forestry nursery at the State College. The diseased plants were destroyed as soon as they were discovered and no

[4]This infection involved only one limb and was eradicated at the time.

blight has been found in this vicinity since that time. The writers found blighted trees in 1927 near Wayne in Wayne county and near Tecumseh and Clinton[4] in Lenawee county. In 1929, the blight was found in seven counties in Michigan, namely: Jackson, Lenawee, Monroe, Oceana,[5] St. Clair, Washtenaw, and Wayne. (Plate IVC.) In 1930, blighted chestnuts were found in Oakland county. Blight infection virtually covers the entire range of the native chestnut in the southeastern part of the State; it is firmly established on planted stock in Lenawee and Jackson counties and in the western part of the State it has killed several planted trees in Oceana county. It can be seen that the blight organism has infected not only the native chestnut but also chestnut which has been planted beyond the natural limits of the distribution of this tree.

The finding of chestnut blight on planted trees near Tecumseh in 1927 presents evidence indicating that the causal organism had been present in the State probably several years previous to its discovery. One of two trees found to be blighted was practically dead, the other nearly half dead. (Plate IV, A and B.) The first tree had only a narrow strip of bark a few inches wide and extending up one side of the trunk for about 15 feet as can be seen in Plate IV B. The remainder of this tree had already lost all of its bark. Examination of this nearly dead tree gave ample evidence of the presence of the blight fungus previous to the death of those parts as well as fresh blight cankers on the remaining living area.

Although the falling of the bark is extremely erratic and, according to Baxter and Gill (1), cannot in itself be used as a criterion for estimating the number of years a tree has been dead, it is evident that chestnut does not become completely decorticated for several years after death. In general, Baxter and Gill find that as much as 23 per cent of the bark-area on the first log remains seven years after the death of the wood. From this determination, which is based upon a great number of trees on numerous permanent and temporary sample plots, it seems safe to conclude that the chestnut blight fungus had been present in this region of Michigan several years prior to 1927.

The fungus has not been reported in the valuable chestnut orchards in the southwestern part of the State. These orchards, however, should be carefully watched as the blight was found by the writers in 1927 in a chestnut orchard of almost 100 trees at Bristol, Indiana. This particular location is within six miles of the Michigan and Cass county southern boundary lines.

Blight Symptoms

The first evidence of this disease is to be found generally on branches and sprouts. If the branches are killed during the growing season, the leaves die and cling to the twigs in very characteristic drooping clusters. This condition of the dead branches persists through the winter. So conspicuous is the appearance of these dead branches with their leaves still hanging on them that they have received the name "flags." (Plate III.) These flags are visible considerable distances from the infected tree and offer one of the first signs of the disease to the observer. In trees which are planted in isolated, exposed places, the breaking of the rather brittle branches in wind storms is of quite common occurrence. At first glance

[5]This infection was first reported by E. C. Mandenberg and H. H. Wedgeworth.

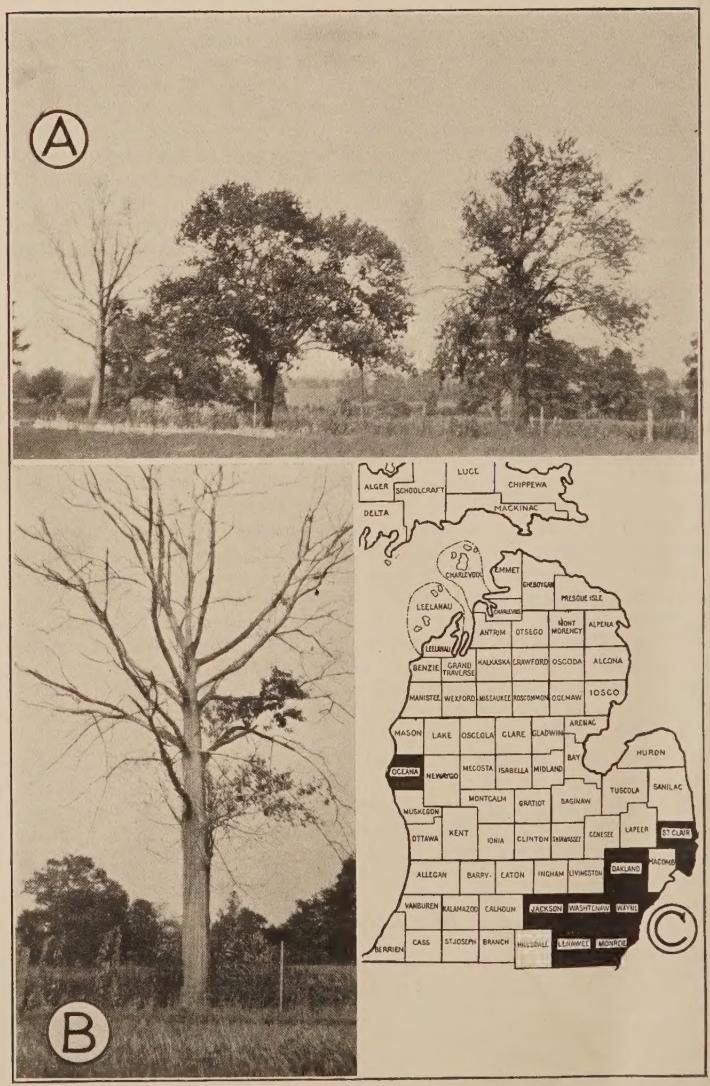

Plate III. A. Blighted chestnut trees found near Tecumseh, Michigan. B. Old blight infected chestnut found near Tecumseh, Michigan. C. Counties in which infected chestnuts have been found.

Plate IV. Native chestnut infected with blight. The characteristic "flag" in the top of the tree indicates an early stage of infection. Wayne, Michigan.

Plate V. A. "A chestnut branch, showing a young blight canker at the base of a side branch in contrast with the rough split older canker on the main stem." Courtesy Office Forest Pathology, U. S. D. A. B. "A chestnut blight canker with swollen edges and with the dead bark peeled from the wood in the center." Courtesy Office Forest Pathology, U. S. D. A.

Plate VI. "Fans of white or buff-colored mycelium of chestnut blight." Courtesy Office of Forest Pathology, U. S. D. A.

branches broken in wind storms have the same appearance as those which have been killed by the chestnut blight organism. Closer inspection, however, shows these branches to be hanging down from the break rather than in the natural position of an unbroken but blight-killed branch. In Michigan, where most of the chestnuts have been planted, many have been observed with broken twigs and larger branches broken by wind storms.

The undersized burrs which are borne on infected branches are also an important and conspicuous sign of the presence of this disease. Close examination of dying twigs and branches or larger parts of the tree shows the presence of cankers. These cankers are more or less elliptical areas of discolored portions of the stem which may be either sunken below or swollen above the surrounding bark. The areas invaded by the causal organism become yellowish-brown in color and gradually spread and enlarge until the branch is completely girdled. The cankered areas may crack open and form longitudinal fissures or checks into the inner bark. (Plate V, A and B.) If the bark is laid back from the cambium region in these cankered areas, layers of the mycelium of the fungous plant are visible as radiating masses, buff-yellow in color. This is a characteristic diagnostic symptom of the disease. Such radiating mats are called mycelial fans. An excellent example of such a fan is shown in Plate VI.

Water sprouts arise below the cankered areas soon after the fungus has made a good growth in the bark. These water sprouts arise due to the stimulus brought about by the interference with the food transfer in the inner cortical region of the bark where the fungus has invaded the food conducting tissues. Although water sprouts are not an infallible sign of this disease, chestnut trees bearing them may be suspected and should be examined more closely especially if these sprouts are being produced in the upper parts of the tree. Another symptom often associated with this disease when the fungus has first attacked the tree in the uppermost branches is "staghead," a condition in which dead leafless branches stand up above the green foliage of the living parts. This symptom is especially noticeable in regions where the chestnut blight fungus has been present for several years. Again, this is not an infallible sign of the disease because other things, such as root rot or change in water level, can bring about this condition.

Causal Organism

The chestnut blight is caused by the fungus *Endothia parasitica* (Murr.) A. and A. As the mycelium penetrates the branch it forms in closely appressed plates of fungous growth already referred to as "mycelial fans." When the fungus has grown for a time there are produced in the bark pycnidial pustules which appear as minute raised papillae. These pustules, which are rarely larger than the head of a pin, are fruiting bodies. Each pycnidium contains enormous numbers of spores known as pycnidiospores. In damp weather sticky spore masses embedded in mucilaginous material ooze out from these bodies in the form of yellowish-orange "spore-horns" or tendrils. (Plate VII.) The presence of these spore horns together with the mycelial fans under the bark furnish infallible macroscopic evidence of this disease, especially when found on living branches. As in many fungi, two forms of spores are produced. Pustules which appear on the surface of the bark as small black dots with minute openings contain the second type of spores produced. (Plate VIII A.) These openings are the mouths of

flask-shaped structures which are buried beneath the surface and which contain the spores known as ascospores. These spores are shot out directly into the air from the mouths of these fruiting structures.

The type of spores which ooze out in the spore-horns are released from their gelatinous matrix when the tendrils or horns become soaked with water in the form of dew or rain. They can be spread by rain splashings, by birds, and by crawling and flying insects. Since these pycnidiospores from the spore-horns are viable and able to germinate after considerable periods of time, days or even months, they constitute active spreading agencies of the fungus. The ascospores which are largely borne away from the diseased area by air currents are also able to disseminate the fungus to considerable distances. Man and other agencies may also bring about the spread of the fungus.

As both types of spores seem to be equally effective in producing infection and as the enormous numbers of both spore types produced are so readily disseminated, it has been impossible to eradicate the chestnut blight from other States, and it will be impossible to eradicate it from Michigan. The blight usually appears as it has in Michigan ahead of the general infection. In such instances it is usually assumed that the sticky spores of the fungus have been carried on the feet of birds.

This organism, being strictly a wound parasite, is unable to invade the tree tissue except through openings previously made in the bark, such as by splits, cuts, or abrasions where the bark has been broken. Once having entered the tissues of the tree the fungus grows with great rapidity and kills the tree. Branches or entire trees are killed by the girdling effect produced by the mycelium, which causes the formation of a cankered area which eventually encircles the twig, branch, or bole.

Previous Attempts at Control or Eradication of Chestnut Blight

Early in the period of invasion of the blight in the eastern forests of the United States it was apparent that the fungus threatened to kill the chestnut throughout the entire commercial range of this species. Realizing the significance of this pest, attempts were made to check the rapid spread of the pest. The strenuous efforts made to completely eradicate and burn the diseased trees in the known infected areas failed to yield the desired results.

In the endeavor to stamp out advance infection, the diseased chestnut in local or spot-infected areas were destroyed, but this method, too, failed to prevent the spread of the blight. Removal of the chestnut in the spot-infection areas did however cause a very pronounced delay in the spread of the blight. Some hope was expressed that possibly the elimination of chestnut from areas surrounding the infected regions might be helpful, but it became evident that the establishment of such immune zones was not an effective method for control. Many other control measures, such as the cutting out of cankers on individual trees, spraying, the injection of chemical compounds into the trees were attempted. Soil treatment was also advocated as a possible means of stimulating growth of the tree and thereby increasing its resistance to the fungus. In addition to the above-mentioned control measures, the establishment of quarantines against transportation of diseased stock was immediately put into effect in hopes that such quarantines would

Plate VII. "Hairlike spore horns which coil out from certain of the blight pustules during damp weather." Courtesy Office Forest Pathology, U. S. D. A. Magnified several times.

Plate VIII. A. "Blight pustules on chestnut." Courtesy Office Forest Pathology, U. S. D. A. B. Seedling trees grown from seeds collected in Korea and Japan.

delay the rapid spread of the fungus. Such quarantine regulations have been very important means of slowing up the spread of the blight across the country. It is no doubt due to these strict quarantine measures that the invasion of this state has been so long after the initial outbreak of this fungous disease in the United States.

Resistant Trees

Since direct efforts for the control of the blight have failed, hope has been expressed by many chestnut owners regarding the development of immunity to the fungus by the native trees. The Office of Forest Pathology (4) and other agencies have made extensive searches for blight resistant plants throughout the entire range of the chestnut, and especially in the regions where the blight has been present for several years. Individual trees have exhibited some differences in their susceptibility but the results of these surveys show that the majority of trees which are seemingly blight-resistant have simply escaped infection. It has also been noted that the many sprouts which so frequently appear at the base of blight-killed trees are merely blight-escaping and do not indicate that the tree has developed a resistance to the fungus. As this new wood becomes infected and dies it is replaced by younger sprouts which in turn escape infection for a period. Although continued effort is being made to locate chestnuts which are immune, there is little evidence at hand which gives immediate promise of the native trees exhibiting even a relatively high degree of resistance.

The European chestnut, *Castanea sativa*, also known as the French, Spanish, and Italian chestnut, is likewise susceptible to the chestnut blight. This chestnut is not, therefore, recommended to the growers for planting purposes in Michigan. A large number of Asiatic species and varieties, however, are less susceptible to the blight, not only in their native habitats but they have exhibited also such resistance in experimental plots and orchards in this country. Some of these trees have indicated a marked resistance to the blight.

In view of these facts, the United States Department of Agriculture has collected thousands of nuts from such blight resistant trees in Korea and Japan. The seedlings obtained from these nuts will be observed for their hardiness and their ability to resist the blight in various parts of the United States. Over 2,000 of these trees have been planted in the vicinity of Ann Arbor, Michigan and an additional number have been set out in south-western Michigan. (Plate VIII B.)

Realizing the desirability of securing more immediate results, efforts have been made to graft scions from Asiatic trees on American stock. In spite of the fact that the scions from many foreign trees have shown resistance, the stocks have succumbed to the blight, resulting, of course, in the death of the entire tree. Experiments in grafting scions from various foreign varieties in Asiatic stock are now in progress at Washington and in other localities in the United States.

Attempts have been made also to hybridize American stock with native chinquapin and with various species and varieties of Asiatic stock. Although it is at present too early to predict the results of these experiments, it seems reasonable to assume that they should yield a highly resistant tree which will produce nuts equal in size and quality to the native chestnut.

The majority of the older orchards and experimental plots in the United States, which contain the Chinese chestnut *Castanea mollissima* and the Japanese chestnut *Castanea crenata* are located in the East. Comparatively little can be said at this time regarding their suitability for planting in Michigan. The chestnut blight organism has been able to attack these trees in orchards in this country but, without doubt, many of these chestnuts exhibit considerable resistance. Undoubtedly, individual specimens of these foreign trees may attain large size in the Orient but the trees already planted in orchards in this country seem to indicate that this foreign stock generally exhibits a small spreading form and rarely grows over forty feet in height. The flavor of the Chinese chestnuts is said to be superior to the Japanese or European species. However, due to the dwarf nature of these trees, it is doubtful if they will ever be of value in forest planting work.

Control and Recommendations

All efforts to control the chestnut blight in the American forests, as well as in orchards where the stock is native, have failed. Many such practices have simply served to prolong the life of the affected trees. It is believed that native chestnut will largely disappear from the State.

Although direct control is impracticable, hope has been expressed by many chestnut owners regarding the development of immunity to the blight by the native trees. Little evidence is to be had at present which supports this view. It seems that the immediate development of the native chestnut to a relatively high degree of resistance to this disease is very remote.

A number of varieties and species of chestnut from China and Japan which have been planted in this country show different degrees of blight resistance. The Office of Forest Pathology, United States Department of Agriculture, has been making an extensive study of chestnut blight in Asiatic stock. This office has found that some of the trees are highly resistant and that the blight can be controlled by constantly pruning out the infections in the infected trees.

Although it is not likely that such foreign stock will ever be planted extensively as forest trees under the present economic conditions, and because of the dwarfed habits of the majority of these foreign trees, Asiatic stock may offer a solution of the problem for the orchardist. The nuts are inferior in quality to those of the American tree but it seems reasonable to expect the results from hybridization experiments to yield a highly resistant tree which produces nuts equal in flavor and size to the Paragon and native chestnut tree.

It is evident that native chestnut trees should not be planted in Michigan orchards and forest plantations. In orchards already established, a careful and frequent examination should be made of the trees. Slight infections should be pruned out and burned in the effort to prolong the life of the tree. Although it is useless to try to save badly infected trees, such trees in the orchard are sources of infection and should be burned promptly.

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